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next week the number of onsets ranged from two to six, the number gradually decreasing. The last case was reported as occurring on the 19th. In all there were 53 cases, 3 of which terminated fatally. The majority of the cases occurred about two weeks after the pollution of the well by the contaminated water of the river.

BIOLOGICAL INVESTIGATION OF CALIFORNIA RICE FIELDS RELATIVE TO MOSQUITO BREEDING.

PROGRESS REPORT.

By W. C. PURDY, Special (Plankton) Expert, United States Public Health Service.

During 1918, an investigation carried on by the writer in Arkansas [1] during the entire rice-growing season furnished the following data:

1. Anopheles mosquitoes (*A. quadrimaculatus*) breed in moderate abundance within the rice fields, as well as in ditches and puddles outside the rice fields.
2. Culex breeds in about the same numbers as Anopheles, both inside and outside the rice fields.
3. Certain enemies of mosquito larvæ (aquatic beetles and their larvæ) are about as numerous on the rice fields as mosquito larvæ themselves.
4. Top-feeding minnows (Gambusia) placed in the rice fields at the rate of 1,400 per acre constitute a check, but not a control, of mosquito production.
5. Oil-soaked sawdust sown broadcast in the rice when the plants are well grown works no injury to the crop and produces an oil film that kills practically all larvæ.

During the rice season of 1919, a similar investigation [2] was carried out in the rice-growing region of northern California. The scope of the work was extended to include (1) examination for mosquito larvæ; (2) a general survey of the larval food supply; (3) the number and kinds of larval enemies; (4) the relative abundance and kinds of algæ present; (5) adult mosquitoes. These were collected weekly from beneath a long, low, concrete bridge near an ideal breeding place.

The outstanding objects of the investigation were as follows:

1. To ascertain the comparative amount of breeding, especially of Anopheles, in the rice fields as compared with simultaneous breeding in seepage puddles, drainage ditches, or other nonrice-field water capable of being treated or the collection of which is preventable.

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[1] Under administrative authority of Assistant Epidemiologist J. C. Geiger. See Jour. Am. Med. Ass'n. Mar. 15, 1919.

[2] Planned in detail by the writer and carried out under his personal supervision. Administrative authority, J. C. Geiger, until Sept. 1; assistant in field work, L. D. Mars, until Aug. 15, 1919.

2. To ascertain the approximate amounts of food (for mosquito larvæ) which was available in the several environments being studied.

3. To ascertain similarly the comparative numbers and kinds of aquatic beetles, bugs, insect larvæ, and fish present, especially those forms of life that are known to prey, to a considerable extent, on mosquito larvæ.

4. To correlate, if possible, the number of mosquito larvæ found in a given environment with the larval food supply available, and also with the larval enemies present.

As a corollary to the item last stated, it became necessary to note such conditions as would afford to mosquito larvæ protection and hiding places from their enemies. Emergent plants, mats of algæ, and drift or floatage are included in this list.

A further factor with probable relation to the available food supply was encountered about mid-season. This was the appearance on the rice fields of very thin, but persistent, films covering practically the entire water surface. These films were therefore studied with a view to ascertaining their probable effect on surface-feeding larvæ, such as Anopheles.

It was the intention to continue the studies of experimental control of breeding in rice fields, and nine plots of rice were accordingly isolated by levees in order that the remedial agents found effective in Arkansas might be further tried out. However, failure of mosquitoes to breed in rice fields made it impossible to continue the study of remedial measures.

Methods.

Counts of mosquito larvæ are based on 14 dips with a dipper holding 400 c. c. These dips were well distributed throughout the puddle, ditch, or plot examined. In the rice plots and rice field 7 dips were taken along the levee and 7 were taken in mid-field. The temperature of the water was taken.

A composite sample for plankton examination was secured by pouring a small portion of the above 14 dips into the plankton bottle. This sample was taken to the laboratory and examined.

Larger forms of life, such as beetles, insect larvæ, and water-bugs, were at first noted by observation only, and their relative numbers expressed as "few," "moderate number," or "many." More accurate records were desirable, however, so the observation method was replaced by another which consisted of taking 28 dips of about 400 c. c. each, and pouring this water into a small muslin bag suspended from the collector's arm. This secured the beetles, insect larvæ, algæ, etc., from about 3 gallons of water. The catch

was taken to the laboratory, examined, and usually preserved for possible further reference.

Since the amount of plankton sample was 112 c. c., it will be noted that the relative volumes of water examined for plankton, for mosquito larvæ, and for beetles and larger life were 112 c. c., 5,600 c. c., and 11,200 c. c., respectively, or in the proportion of 1, 50, and 100.

Findings.

1. Mosquitoes breed only in very small numbers within the rice-fields examined.

This statement is based on 120 examinations, of 14 dips each, made on 9 rice plots of one-fifth acre each, and on a large rice field adjoining. Examinations began late in June, after water had been on the fields about 10 days, and continued until the latter part of September, when the fields were drained. The 120 examinations netted only 127 larvæ, about half of these being Anopheles.

2. Mosquitoes breed in moderate numbers in a long roadside puddle, the water of which seeps directly from the canal which, a hundred yards farther on, furnishes water to the rice fields examined.

Twelve examinations were made, extending throughout the rice-growing season. The total number of larvæ taken was 59, of which 30 were Anopheles.

3. Mosquitoes breed in large numbers in small natural drainage ditches which meander across the nearly level valley.

Twenty-six examinations were made in two such ditches during the rice-growing period. The total number of larvæ was 1,144, of which 724 were Anopheles.

4. Examination of plankton samples showed that approximately equal quantities of larval food were available in all three situations—the rice fields, the seepage puddle, and the natural ditches.

Thirty samples from the rice fields showed an average content of 124 parts per million (by volume) of larval food; eleven samples from the seepage puddle gave an average of 138 parts per million; twenty-one samples from the natural ditches averaged 119 parts per million.

5. Collections of the larger organisms showed that larval enemies were less numerous in rice fields, where mosquito larvæ were so few, than they were in either the seepage puddle or the natural ditches, where mosquito larvæ were relatively numerous.

Twenty-nine collections made in rice fields yielded an average of 5 known larval enemies; eleven collections from the seepage puddle averaged 12 enemies; and 20 collections from the two natural ditches gave an average of 16 enemies.

6. Blue-green algæ were present in large quantities in the rice fields. These algæ were less abundant in the seepage puddle. The natural drainage ditches contained large amounts of green algæ, with relatively small amounts of the blue-greens.

7. In the latter part of July, light films appeared on the rice fields, covering practically the entire surface. These films persisted for the remainder of the season. The seepage puddle had a somewhat similar history as to the films. No films were observed on the water of the natural ditches.

8. The water on the rice fields was practically stagnant, and after midseason apparently acquired a degree of foulness which was due in all probability to the gradual decay of the large amount of blue-green algæ present. Water in the roadside seepage puddle showed very similar conditions. Water in the natural ditches, on the other hand, appeared to be in fresher condition throughout the season.

9. Temperatures of the water were practically identical in rice fields, seepage puddle, and natural ditches throughout the season.

Discussion.

LACK OF BREEDING IN THE RICE FIELDS.

Practical absence of mosquito-breeding in the rice fields studied in California is doubtless the most noteworthy finding of our investigation thus far. At present no adequate explanation is available for these negative results, especially when similar investigations have shown positive results from Arkansas rice fields. Pending the outcome of certain field tests about to be carried out relative to the possible cause of these negative results, it may be well to state the following facts:

(1) Blue-green algæ are very abundant in the California fields studied, and green algæ are relatively scarce. In Arkansas fields green algæ predominate, but the growth is not very heavy as a rule.

(2) In the California fields studied, surface films appeared about July 20 and persisted for the remainder of the season. Such films were not observed on the Arkansas fields at any time during the season. The frequent heavy rains would probably prevent their formation, even if other conditions were favorable.

(3) Weather conditions differ. In California there is no rain, as a rule, during the entire rice season, while in Arkansas rains are frequent and heavy during this period, sometimes adding, within 36 hours, an inch or more to the depth of water in the rice fields.

(4) The water in the California fields is practically stagnant and to a considerable degree impure for the latter two-thirds of the rice season. This is apparently due (*a*) to its cost and consequent retention on the fields for practically the entire rice season (escaping meantime chiefly by evaporation), until the fields are drained for harvest; (*b*) to the decay of the heavy growth of blue-green algæ, with no movement of water to remove the products of decay; and (*c*) to lack of rain, which further conduces to the concentration of products of decomposition and to general stagnation.

On the other hand, Arkansas fields, watered from wells, are (*a*) subject to more change of the water content, occasional partial drainage being the frequent practice; also (*b*) there is less algal growth to decay and more opportunity for removal of products of decay. Finally, (*c*) frequent heavy rains freshen the water perceptibly.

THE SURFACE FILMS.

The surface films are largely biological in their composition, being composed of various minute algæ (chiefly unicellular, but also the minute beginnings of several of the filamentous algæ), many diatoms,

frequent rhizopods, especially *Arcella* and *Difflugia,* and a sprinkling of various protozoa and rotifers. Small growths of *Anthophysa* are sometimes quite abundant in these films. Stained specimens of intact films show bacteria in large numbers. Finally, a yellowish-brown flaky material of unknown origin usually occupies all otherwise vacant spaces and seems to bind the whole together, to some extent.

The common "water bloom," composed chiefly of *Euglena,* was observed on portions of the fields early in the season (June) and the first persistent films (July 18 to 30) contained large numbers of *Euglena.* This organism then practically disappeared from the films.

Anopheles larvæ introduced into these later films (in September) seemed to experience no discomfort for several days. They lay immediately beneath the film, with their breathing tube apparently breaking or penetrating it, thus securing air. It is possible that the food supply furnished by this film was not entirely suitable, for most of the larvæ gradually disappeared, only a very small percentage of them reaching the imago stage.

THE FOOD OF MOSQUITO LARVÆ.

Recent work by Dr. Metz [3] shows that Anopheles larvæ will thrive on nonliving organic food of various kinds, mainly of vegetable origin. Observations by various workers agree generally that the larvæ are mainly surface feeders; that in feeding they produce with their mouth-brushes a current of water, which, passing into the mouth cavity, carries with it the various particles of food, which are then collected at the beginning of the gullet and swallowed. Miss Cora A. Smith (Psyche, 1914, Vol. XXI, pp. 1–19) notes that larvæ flourished in a pool containing dead leaves, but the water was clear, with no algæ or other material which might be regarded as the source of larval food.

The observations of the writer in his official capacity [4] may be of interest in this matter. In examining water to ascertain the content of minute (microscopic) plants and animals collectively termed the plankton, it has repeatedly been noted that water which appeared practically clear to the unaided eye contained so many microscopic organisms, especially diatoms, that the filters used for securing these organisms were speedily clogged. While this is by no means always the case, yet it seems plain that we can not judge by the apparent clearness of the water alone, whether larval food is abundant or scarce. As a convenient means of demonstrating the fact just

[3] Observations on the Food of Anopheles Larvæ. Reprint No. 549 from Public Health Reports, Aug. 8, 1919.

[4] Plankton Expert, United States Public Health Service.

stated, it is suggested that Anopheles larvæ be placed in a watch-glass of apparently clear but unfiltered water (as from a ditch or puddle), and the feeding process of the larvæ observed under low magnification. It will be seen that visible masses of food accumulate in the semitransparent "throat" of the larva, and are swallowed at the rate of 7 to 10 times per minute, although inspection with the unaided eye would seem to indicate that no food is present in the water.

A second matter of importance is the fact that such organisms as have considerable power of swimming are able to resist the current set up by the mouth-brushes of the larva, and thus escape. The writer has repeatedly observed that larval stages (naupleii) of *Cyclops* or other crustacea were always able to escape, as were also certain of the more active rotifers and ciliates. The organisms mentioned were *small* enough to serve as food for the larva, but their activity saved them from this fate. In general, it may be stated that any sufficiently minute, freely-floating object or weakly-swimming organism that comes within the current of water produced by the larval mouth-brushes will be included in the larval diet.[5]

Examination (by the writer) of the contents of the food canal of several larvæ shows striking agreement with the above proposition. In every case the food tract was packed with the remains of various organisms, all of which were recognized as forms either without power of locomotion or with very limited powers. In no case was an organism found which, in life, was known to possess such power of locomotion as is exhibited by the more active rotifers, ciliates, and crustacea. Some masses of inert matter and detritus were present also.

A study of Table II is worth while in this connection. Most of the organisms listed were easily recognizable. Doubtless other less resistant organisms had been digested. There were masses of material in all the food tracts examined which could not be identified. Even with this drawback, however, the list of recognizable forms is a fairly long one, and will serve to emphasize the fact noted by many observers, viz., that the larva is an omnivorous and heavy feeder.

It would seem well-nigh impossible to control production of Anopheles by any practicable treatment of the larval food supply, inasmuch as this food is made up of a great variety of microscopic organisms, both plant and animal. Moreover, if the organisms be killed or removed, the nonliving organic detritus will still suffice for the larval food supply, as Dr. Metz has shown in the publication cited.

[5] Particles of carmine, administered by the writer, have been swallowed, have traversed the larval alimentary tract, and have been ejected at the anus 31 minutes and 45 minutes, respectively, after having been swallowed.

TABLE I.—*Averages (monthly and seasonal) of weekly examinations of rice field, seepage puddle, and natural ditches during rice season, June 15 to Oct. 1, 1920 (California).*

Source of samples.	Month.	Temperature of water (C.).	Larval food (Plankton): Parts per million (by volume) in 1 c. c. of water.	Larval enemies in 28 dips of 400 c. c. each.	Mosquito larvæ in 14 dips of 400 c. c. each.		
					Anopheles.	Culex.	Total.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Rice field and rice plots	June	23	107	10	....	1	1
Do	July	21	106	5	....	1	1
Do	August	20	137	6	....	$\frac{1}{3}$	$\frac{1}{3}$
Do	September	16	137	3	$1\frac{1}{2}$	....	$1\frac{1}{2}$
Examinations made	....	....	30	29	120	....	....
Seasonal average per examination.	....	....	124	5	$\frac{1}{2}$	$\frac{1}{2}$	1
Seepage puddle	June	22	127	14	9	2	11
Do	July	21	113	12	1	7	8
Do	August	21	144	14	3	....	3
Do	September	16	160	10	5	4	9
Examinations made	....	....	11	11	12	....	....
Seasonal average per examination.	....	....	138	12	$2\frac{1}{2}$	$2\frac{1}{2}$	5
Natural ditches	June	22	135	13	12	10	22
Do	July	19	116	20	16	7	23
Do	August	20	91	18	25	13	38
Do	September	16	151	10	58	38	96
Examinations made	....	....	21	20	26	....	....
Seasonal average per examination.	....	....	119	16	28	16	44

NOTE.—See Charts I to VI, inclusive.

TABLE II.—*Contents of food tracts of four anopheles larvæ.*

No.	Length of larva (inch).	Plants.								Animals.									Molts, fragments, scales, etc.
		Diatoms.	Protococcus.	Staurastum.	Scenedesmus.	Spores.	Conifer pollen.	Fungus.	Alga filaments (length).	Arcella.	Difflugia.	Chlamydomonas.	Trachelomonas.	Volvox.	Tintinnus.	Halteria.	Rotifers.	Unidentified.	
									mm.										
1	$\frac{1}{4}$	40	.....	5	.....	.....	19	.....	5.1	9	4	10	.....	6	.....	.....	9	.....	(1)
2	$\frac{1}{4}$	.....	.....	.....	.....	13	49	2	10.3	33	6	.....	8	.....	1	1	10	23	5
3	$\frac{3}{16}$	27	24	8	1	728	3	.....	.2	7	.....	10	83	5	.....	2	10	7	11
4	$\frac{1}{4}$	29	26	1	.....	.....	6	1	4.4	6	3	.....	8	20	.....	.....	9	.....	9
[2] 5	.....	.....	.....	.....	(2)	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....

[1] Many wing scales present.
[2] *Culex* larva, taken from water in a tub. Its food tract was packed with *Scenedesmus*. Practically no other organisms were present.

We thus know from the observation of the feeding habits, from dissection of several larvæ, and from a knowledge of the organisms that constitute the microscopic plankton, (1) that the Anopheles larva secures its food by producing with its mouth-brushes a minute but rapid current of water which passes within the mouthparts of the larva; (2) that this current carries into the mouth any sufficiently minute particles of matter which are held in suspension in the water; (3) that freely-floating organisms, both plant and animal, are similarly drawn into the mouth by this current, with the exception of certain organisms which, by vigorous swimming, are able to withstand this current; and (4) that the larva has, so far as present knowledge goes, no power of selection of its food other than to reject such fragments as are too large.

Keeping the above points in mind we have made an effort to approximate the amount of larval food available in different waters where breeding of mosquitoes might be expected, or was actually in progress. This was done in the hope of determining, if possible, some basic facts relative to the amount and kinds of food required by the larvæ, in order that measures for control of breeding by reducing the food supply might be considered, or the impracticability of such measures pointed out.

The plankton catches from representative composite samples of water were examined under the microscope and five fields were counted and the results expressed in cubic standard units per 1 cubic centimeter of water. (A cubic standard unit is a cube, the edge of which is 20 microns long.)

The minute detritus present in each field was similarly measured. This procedure placed all organisms, large and small, and all minute detritus, on the same volumetric basis. These plankton examinations were made at weekly or 10-day intervals throughout the season of each environment studied.

The total volume of those organisms that were suitable for larval food was now obtained by simply adding the results obtained by examining the five fields. (This did not include such organisms as were too large, or such as had vigorous powers of swimming.) To this was added three-fourths of the volume of minute detritus present in these same fields. This was thought to be a very conservative figure in as much as the feeding larva takes in practically everything that comes within the reach of the current produced by its mouth-brushes. The total, expressed in cubic standard units, was then reduced to parts per million (by volume) and is thus stated in Table I.

We are thus enabled to estimate with a fair degree of accuracy the available food supply for larvæ in the several environments studied. While the values for single examinations (not given in this brief report) fluctuate considerably, owing to the sudden growth of some particular group of organisms, or their equally sudden subsidence,

it is significant that the average results for the season and for the three environments are very similar in values. It would seem to follow, therefore, that the wide variations in larvæ production noted in these three situations during the season can not be explained on the basis of differences in larval food supply.

ENEMIES OF MOSQUITO LARVÆ.

These may be classed as follows, in the order of their observed efficiency in devouring mosquito larvæ: (1) Top-feeding minnows; (2) larvæ of Dytiscid beetles; (3) the smaller adult beetles of the Dytiscid group; (4) damsel-fly larvæ and nymphs; (5) water boatmen and back-swimmers; and (6) Hydrophilus larvæ.

It should be understood that this classification is based on somewhat limited observation, and that further investigation may result in changing the order given or in adding to the list.

It is to be noted, further, that these predacious organisms do not limit their depredations to mosquito larvæ. They prey on other organisms, and on one another to some extent. It follows that their abundance or scarcity in a given environment does not *necessarily* mean that mosquito larvæ will be few or many, unless other available food be absent—a condition which is practically impossible under natural conditions. It is nevertheless true that an excessive number of known enemies (such as fish) may be introduced into a given pond or water body with good results as regards the decrease in mosquito larvæ and in other fish foods as well. Moreover, these good results are dependent in no small degree upon the absence of such amounts of drift, débris, emergent plants, and mats of algæ as would furnish effective hiding places for the larvæ.

In the three situations studied, top-feeding minnows were absent. (Minnows, *Gambusia*, were numerous in Arkansas rice fields). The other enemies named were present in California waters in varying numbers throughout the season. In the table given (Table I) the kinds of enemies are not named, but it may be here stated that damsel-fly larvæ and small beetles were numerically predominant.

Attention is directed to the fact that comparable examinations in the three environments showed, throughout the season, that the situation furnishing the smallest number of larvæ (the rice fields) showed the presence of only one-third the average number of enemies that was found in the situation furnishing the largest number of larvæ (the ditches). This is precisely opposite to what we would expect if these larval enemies were to be regarded as an index of the amount of mosquito breeding. Evidently the larval counts obtained can not be explained on the basis of depredations made by the enemies found to be present in the respective environments.

On inspection of Charts I to VI (plotted from data in Table I) it will be noted that all three environments show an increase of breeding in

September (Chart I), but that there is no proportional increase of larval food in this month (Chart II). There is, however, a considerable but not proportional decrease of enemies, which doubtless has its effect in materially increasing the larval output. It is to be noted, however, that both puddle and rice fields show a heavy decrease of larvæ in August (Chart I) for which the very slight increase in enemies (Chart III) seems to be inadequate explanation.

The environment exhibiting unimpaired natural conditions presents also (Chart VI) the most consistent data attending the larval history. Chart VI shows that the increase of larvæ in August was attended by some decrease in larval enemies, though there was a decrease of larval food also, the latter seemingly inconsistent. In September, however, increase in larvæ is attended by fairly proportional increase of food and decrease of enemies.

IMAGO COLLECTIONS.

Collections of adult mosquitoes were made nearly every week, and were continued throughout the winter, which season is very mild in this portion of California, the temperature rarely reaching the freezing point. All collections were made over a definite area on the undersurface of a low concrete bridge that spanned a broad, grassy, natural drainage ditch, which formed an ideal breeding place. No other suitable shelters for mosquitoes were to be found within three-fourths of a mile, except similar bridges a quarter mile distant. All mosquitoes were identified by Prof. S. B. Freeborn, entomologist of the University of California, either personally or under his direction. Mr. L. D. Mars assisted in making identifications.

These collections, begun in June, 1919, and still going on at this writing (May, 1920), may be briefly summarized as follows:

(1) *Anopheles occidentalis* was found in every collection except two—January 23 and April 17. In 30 of the 42 collections recorded, this species outnumbered the combined totals of all other mosquitoes taken. In 5 collections males outnumbered females. Males were present in every collection until November 19. On and after this date no males were found throughout the winter and spring until April 27, 1920, when 2 males were taken. The largest catch of *A. occidentalis*, numbering 794 males and 952 females—a total of 1,746—was made on September 25, 1919. In the latter part of November and during December and January very few were to be found, the number varying from 1 to 8 (except Jan. 23, when none was present). About February 1 the numbers increased, as many as 24 (all females) being taken in one catch. Numbers again decreased in March and April.

(2) The only other anopheline found in numbers was *A. pseudopunctipennis*. This appeared in July collections, and in two catches

CHART I.—MOSQUITO LARVAE PER EXAMINATION. MONTHLY AVERAGES.

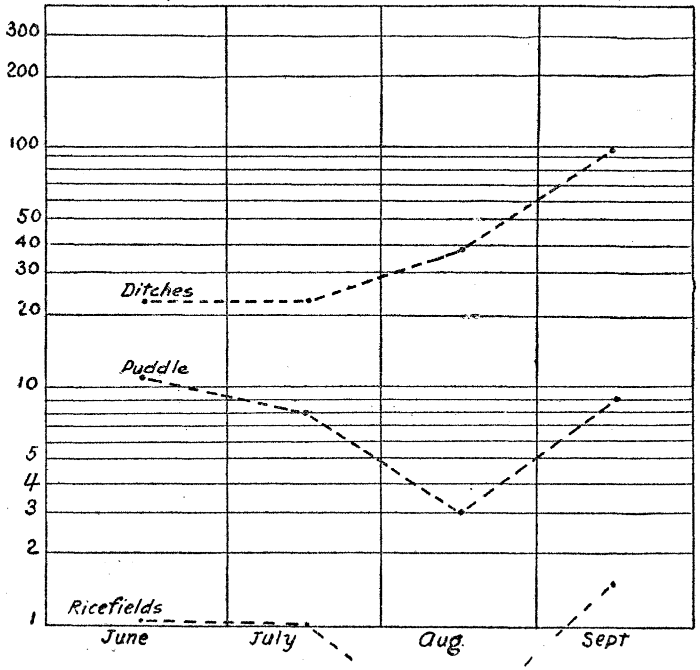
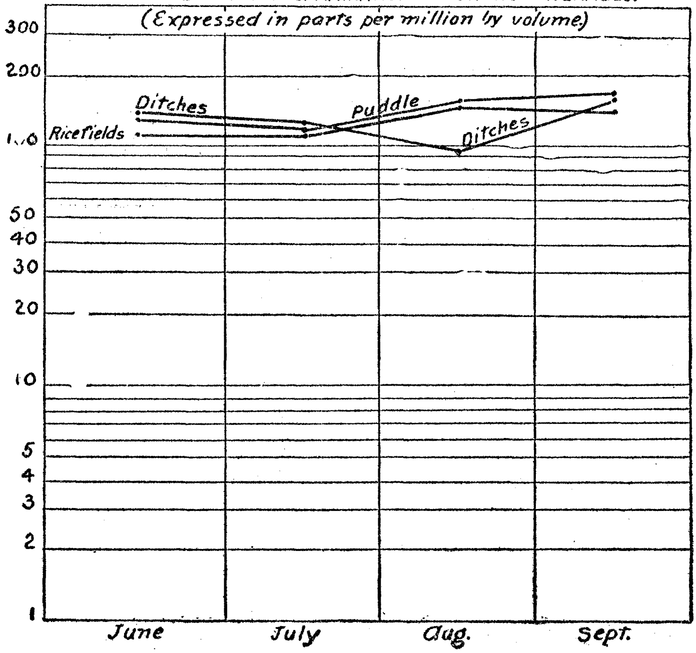


CHART II:—LARVAL FOOD PER EXAMINATION. MONTHLY AVERAGES.

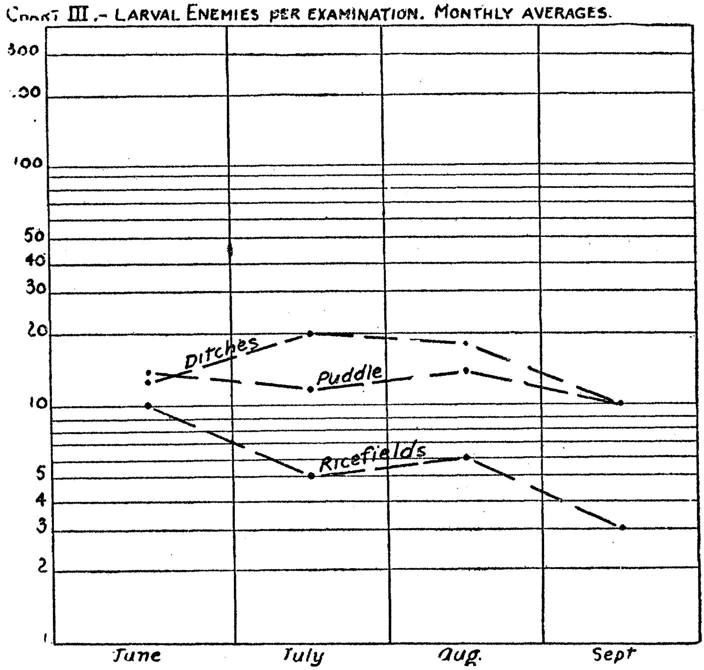
(Expressed in parts per million by volume)



during this month outnumbered *A. occidentalis.* However, *pseudo-punctipennis* occurred in only 15 of the 42 collections recorded, none being found after October 8, except a single specimen (female) on December 6, and February 13, respectively. A single specimen of *A. punctipennis* (female) was found April 27, 1920.

(3) The most prevalent culicines were *C. tarsalis* and *Aedes currei.* The former was fairly abundant from June to October and outnumbered *A. occidentalis* in 7 collections in July and August. It was found occasionally during November to April, but always in very small numbers. *Aedes currei* occurred in moderate numbers during June to October, but was absent during November to April, except a single specimen taken November 12. *Culiseta incidens* appeared in small numbers in 10 collections, *Aedes varipalpus* in 6, *Culiseta*

CHART III.- LARVAL ENEMIES PER EXAMINATION. MONTHLY AVERAGES.



inornatus in 3, and *Culex erythrothorax* and *stigmatosoma* in a single collection each. The average number per collection of these 5 varieties combined was less than 3.

Summary.

Investigations on one California rice ranch and on near-by waters, carried on during the season of 1919, would seem to indicate:

(1) That breeding of mosquitoes (both Anopheles and Culex) is practically absent from the rice fields themselves, but that moderate or heavy production is going on meantime in near-by seepage puddles and natural drainage ditches. The season's investigation shows that for 1 mosquito produced by the rice fields the seepage puddle produces 5 and the natural ditches 44.

CHART IV.—MONTHLY AVERAGES PER EXAMINATION IN RICEFIELDS.

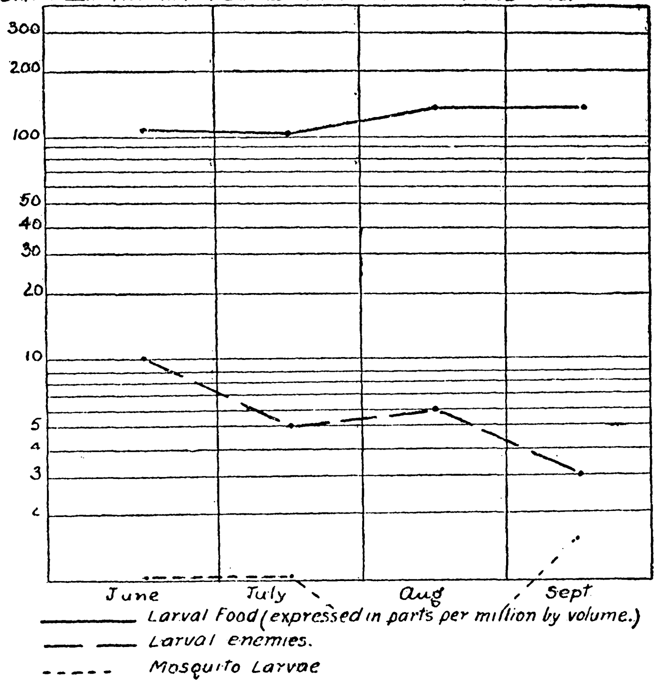
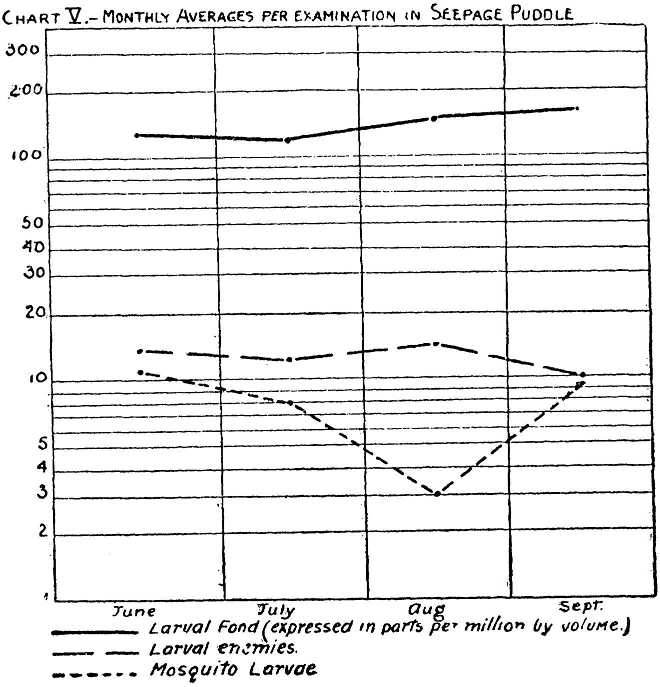


CHART V.—MONTHLY AVERAGES PER EXAMINATION IN SEEPAGE PUDDLE

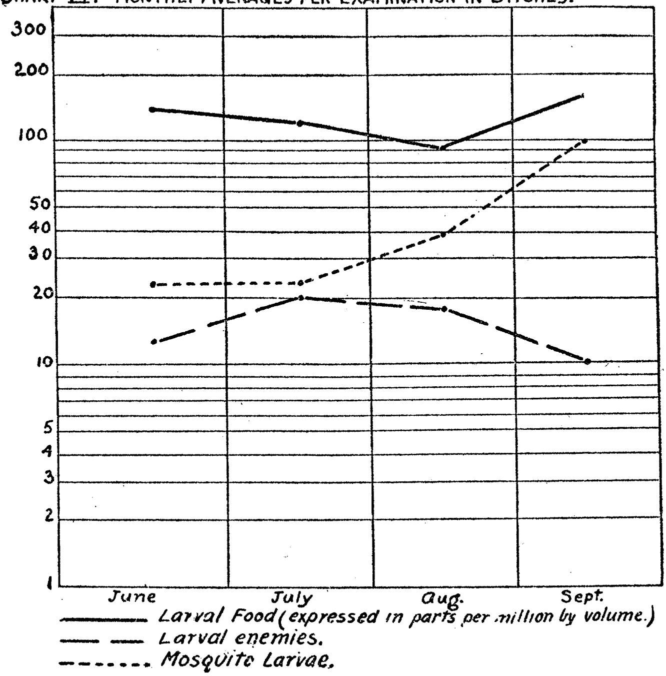


(2) That the larval food supply, being about equal in quantity and comparable in kind in rice fields, in puddle, and in ditches, is evidently not responsible for the great discrepancy in numbers of larvæ.

(3) That the discrepancy is not entirely due to activity of larval enemies, because these are most numerous where larvæ are most abundant, and least numerous where larvæ are practically absent.

(4) That heavy growth of blue-green algæ and the presence of surface films on rice fields constitute the most noticeable differences between these nonbreeding places, the rice fields, and the heavily breeding places, the ditches, where films are absent and blue-green algæ are not abundant.

CHART VI.—MONTHLY AVERAGES PER EXAMINATION IN DITCHES.



(5) That the seepage puddle repeated, on a larger scale, the fluctuations of the rice fields in numbers of larvæ, in food content, and in number of enemies.

(6) That it is apparently out of the question to control mosquito production in natural uncared-for waters, including rice fields, by attempting to diminish the larval food supply, or by the introduction of natural enemies, with the exception of certain fish.

(7) That the natural mechanism of control as found in the California fields seems to be concerned, in part at least, with the general condition of stagnation, the large amount of blue-green algæ, and the biological surface films. These conditions prevailed on the rice fields from July 20 (about) to the latter part of September.

(8) That the conditions just stated fail to account for the negative results obtained during June and part of July.

(9) That collections of imagoes show *A. occidentalis* (thought to be an efficient vector of malaria) to be present throughout the year and to be present very abundantly in August and September. Males probably do not live through the winter, for none could be found from November 19 to April 27.

Recommendations.

It is urged that the negative results from California rice fields be confirmed or disproved by further investigation which shall be made on four or five fields in different parts of the State.

It is further recommended that intensive studies be made of certain biological, chemical, and physical conditions that obtain in a nonbreeding field, to determine, if possible, the reason for the negative results.

TRAVELING PUBLICITY CAMPAIGNS IN HEALTH WORK.

The old-time peddler with his pack of goods for sale and the patent-medicine man with his shows and illustrated lectures of misinformation and his dubious wares are forms of publicity campaigns long familiar in rural districts. The modern educational tour on wheels carries facts and instruction in this same very effective manner directly to the people; and many State health departments have found that such traveling campaigns, with their exhibits and lectures, afford a valuable means of carrying on public-health work.

The activities of these modern peddlers have been described in a book recently issued by the Russell Sage Foundation, "Traveling Publicity Campaigns—Educational Tours of Railroad Trains and Motor Vehicles."[1] The book deals with the use of traveling publicity campaigns by many National and State Government bureaus and by private organizations. Its purpose and scope are set forth in the following paragraph contained in the introduction:

"Believing that this method of promoting social programs will continue to be employed, whatever the type of vehicle used to convey travelers and their outfits, we have gathered information about a number of campaigns and offer it here, together with comments and suggestions, for the benefit of those who may be considering the method for the first time or who have tried it and wish to compare their experiences with those of others. The descriptions and suggestions are drawn from accounts of about 75 tours of trains, trucks, trolley cars, and other vehicles, obtained from printed reports, articles, letters, replies to questionnaires, and interviews, as well as from the observations and experience of the writer."

The information contained may be of value to health organizations intending to make use of this educational method in their public-health work.

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[1] Traveling Publicity Campaigns—Educational Tours of Railroad Trains and Motor Vehicles. By Mary Swain Routzahn, xi+151 pp. Wm. F. Tell Co., Philadelphia.